

Prediction of Psychopathology and Functional Impairment by Positive and Negative Schizotypy in the Chapmans' Ten-year Longitudinal Study

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Abstract:

The present study examined the predictive validity of psychometrically assessed positive and negative schizotypy in the Chapmans' 10-year longitudinal data set. Schizotypy provides a useful construct for understanding the etiology and development of schizophrenia and related disorders. Schizotypy and schizophrenia share a common multidimensional structure that includes positive and negative symptom dimensions. Recent cross-sectional studies have supported the validity of psychometric positive and negative schizotypy; however, the present study is the first to examine the predictive validity of these dimensions. The Chapmans' longitudinal data provided an ideal opportunity because of the large sample size, high reassessment rate, and extended interval between assessments. A total of 534 psychometric high-risk and control participants were initially assessed, and 95% of this sample was reinterviewed 10 years later. As hypothesized, positive and negative schizotypy uniquely predicted the development of schizophrenia-spectrum disorders. At the reassessment, both positive and negative schizotypy predicted psychotic-like, schizotypal, and paranoid symptoms, as well as poorer adjustment. The positive dimension was associated with mood and substance use disorders and mental health treatment. Negative schizotypy was associated with schizoid symptoms and social impairment at the follow-up. The results extend the growing validity findings for psychometrically assessed positive and negative schizotypy by demonstrating that they are associated with the development of differential patterns of symptoms and impairment.

Keywords: Psychopathology | Psychosis | Negative schizotypy | Positive schizotypy | Psychosis-proneness | Schizophrenia | Functional impairment

Article:

As schizotypy enters its sixth decade, it remains a valuable and evolving construct for considering individual differences and specifically for understanding vulnerability for schizophrenia-spectrum psychopathology (Claridge, 1997; Lenzenweger, 2010; Meehl, 1962, 1990; Rado, 1956). Since the time of Paul Meehl's landmark address to the American Psychological Association in 1962, schizotypy has evolved from a relatively homogenous phenotype linked to a single-gene model of liability for schizophrenia to a broader, multidimensional construct. Although the exact nature of schizotypy is not universally agreed on (see landmark texts by Claridge [1997] and Lenzenweger [2010] for opposing viewpoints), we conceptualize schizotypy as a continuum of schizophrenia-like manifestations ranging from minimal impairment, to subclinical deviance, to personality pathology, to full-blown psychosis (Kwapil, Barrantes-Vidal, & Silvia, 2008). Thus, schizotypy conveys the vulnerability for schizophrenia-spectrum disorders, although the majority of schizotypic individuals are not expected to develop psychosis. The study of schizotypy is useful for understanding the etiology and development of schizophrenia and related disorders, in part because it avoids third-variable confounds such as medication, stigma, and institutionalization arising from schizophrenia. The reliable identification of schizotypic individuals should facilitate our understanding of relevant etiological factors and developmental trajectories, clarify risk and protective agents, and provide a necessary step toward development of preventative treatments.

Schizotypy and, by extension, schizophrenia are heterogeneous. This heterogeneity occurs at the phenotypic level, with symptoms and impairment ranging from marked diminution (e.g., alogia) to marked excesses (e.g., hallucinations) in behavior. Furthermore, this heterogeneity is evident at the etiological, developmental, and treatment-response levels. Thus, treating schizotypy and schizophrenia as homogenous constructs impedes our ability to understand the origins, development, and expression of these complex conditions (Kwapil & Barrantes-Vidal, 2012). The heterogeneity of schizotypy and schizophrenia appear to be characterized by a common multidimensional structure. Factor analytic studies suggest that positive, negative, and disorganized dimensions underlie schizophrenia (Lenzenweger & Dworkin, 1996; Liddle, 1987). Consistent with the factor structure of schizophrenia, positive and negative factors of schizotypy are the most replicated dimensions (Cicero & Kerns, 2010; Kwapil et al., 2008; Vollema & van den Bosch, 1995). The reliable identification and measurement of these dimensions is essential for parsing the heterogeneity of schizotypy and schizophrenia.

Recent research indicates that two factors underlie the Wisconsin Schizotypy Scales, which are comprised of the Perceptual Aberration (Chapman, Chapman, & Raulin, 1978), Magical Ideation (Eckblad & Chapman, 1983), Physical Anhedonia (Chapman, Chapman, & Raulin, 1976), and Revised Social Anhedonia (Eckblad, Chapman, Chapman, & Mishlove, 1982) Scales. Exploratory and confirmatory factor analyses reliably identify positive and negative schizotypy dimensions that account for approximately 80% of the variance in the measures (e.g., Lewandowski et al., 2006; Brown, Silvia, Myin-Germeys, Lewandowski, & Kwapil,

2008; Kwapil et al., 2008). This factor structure has been replicated in cross-cultural studies (e.g., Kwapil, Ros-Morente, Silvia, & Barrantes-Vidal, 2012). Furthermore, studies indicated that the positive and negative schizotypy dimensions are associated with differential patterns of symptoms and impairments in cross-sectional questionnaire studies (e.g., Lewandowski et al., 2006), interview studies (e.g., Kwapil et al., 2008; Barrantes-Vidal et al., 2013), laboratory studies (Kaczorowski, Barrantes-Vidal, & Kwapil, 2009), and experience sampling studies (e.g., Kwapil, Brown, Silvia, Myin-Germeys, & Barrantes-Vidal, 2012). Consistent with deficits reported in positive and negative symptom schizophrenia, Kwapil et al. (2008) indicated that the positive and negative schizotypy dimensions were differentially related to psychopathology, personality, and social functioning. Both schizotypy dimensions were associated with schizotypal and paranoid personality disorder symptoms. Positive schizotypy was uniquely related to psychotic-like experiences, substance abuse, mood disorders, and mental health treatment, whereas negative schizotypy was specifically associated with negative and schizoid symptoms. Both dimensions were associated with poorer overall and social functioning, but negative schizotypy was associated with decreased likelihood of intimate relationships. Furthermore, Barrantes-Vidal et al. (2013) indicated that the schizotypy dimensions are associated with prodromal symptoms in a nonclinically identified sample.

These initial findings support the construct validity of psychometrically assessed positive and negative schizotypy dimensions. However, this work has been limited to cross-sectional studies. The present study examined the predictive validity of the schizotypy dimensions using data from the Chapmans' 10-year longitudinal study of psychosis proneness (e.g., Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Kwapil, 1998). The Chapmans' study was the first longitudinal assessment of psychometric high risk and it was notable for its large sample, high reassessment rate, and 10-year follow-up interval. They interviewed 534 college students at the initial assessment and reassessed 95% of the sample 10 years later. The study used a psychometric high-risk approach in which participants were assigned to five groups: (1) high scorers on Perceptual Aberration or Magical Ideation (PerMag) Scales, (2) high scorers on the Impulsive-Nonconformity Scale (Chapman et al., 1984), (3) high scorers on the Physical Anhedonia Scale, (4) a combined-risk group, and (5) a control group. However, the study did not examine the dimensional structure underlying the psychometric measures.

At the cross-sectional assessment, the high-risk groups exceeded the control participants on psychotic-like experiences and schizotypal symptoms. Chapman et al. (1994) noted that the PerMag group was especially deviant. Note that none of the participants were psychotic at the time of the initial assessment. At the 10-year reassessment, 14 participants had developed *DSM-III-R* (American Psychiatric Association, 1987) psychotic disorders and 30 met criteria for schizophrenia-spectrum disorders including schizotypal, schizoid, and paranoid personality disorders. The PerMag group exceeded the control group on rates of psychotic disorders, as well as on ratings of psychotic-like, schizotypal, and paranoid symptoms. They also had poorer overall functioning and elevated rates of mood and substance use disorders. None of the other

groups exhibited elevated rates of psychotic disorders. Although participants in the longitudinal study were not selected based on scores on the Revised Social Anhedonia Scale, Kwapil (1998) reported that scores on the scale predicted elevated rates of schizophrenia-spectrum disorders, as well as psychotic-like, schizotypal, schizoid, and paranoid symptoms.

The primary goal of the present study was to investigate the predictive validity of psychometrically assessed positive and negative schizotypy using data from the Chapmans' longitudinal study. The validity of these dimensions has been supported in a variety of cross-sectional studies, but this provided the first examination of their predictive validity. This longitudinal data set provides an ideal vehicle for this purpose. Based on cross-sectional findings (e.g., Kwapil et al., 2008; Gross, Silvia, Barrantes-Vidal, & Kwapil, 2013), it was hypothesized that the positive and negative schizotypy dimensions would predict differential patterns of psychopathology and impairment at both assessments. Specifically, it was hypothesized that both dimensions would predict schizotypal and paranoid symptoms and functional impairment. Further, it was expected that positive schizotypy would predict psychotic-like experiences, mood disorder symptoms, and substance abuse at both time points and that negative schizotypy would predict schizoid symptoms. Most importantly, it was hypothesized that both dimensions would predict the development of schizophrenia-spectrum disorders at the reassessment.

Method

Participants

The present study used data from the Chapmans' longitudinal study of psychosis-proneness. The method is described below, but additional details can be found in Chapman et al. (1994) and Kwapil (1996, 1998).

Initial assessment

A total of 534 students enrolled at the University of Wisconsin-Madison participated in the initial assessment (mean age = 19.3 years, $SD = 1.4$; 52% female). These participants were initially selected from a pool of approximately 8,000 undergraduates who completed the Wisconsin Schizotypy Scales in mass screening sessions over the course of seven semesters. High-risk participants were recruited based on standard scores of at least 1.96 on the Perceptual Aberration or Magical Ideation Scales ($n = 193$), Physical Anhedonia Scale ($n = 75$), or Impulsive-Nonconformity Scale ($n = 74$). A combined risk group included 33 participants whose sum of their standard scores on the four scales was at least 3.0. Additionally, 159 control participants were included who had standard scores on each of the four scales of less than 0.5. Note that consistent with our hypotheses there was not any group assignment used in the present study or any group comparisons conducted.

10-year follow-up assessment

A total of 508 of the original participants (95%) were reinterviewed (mean age = 30.0 years, $SD = 1.7$; 52% female). Participants who completed the reassessment did not differ from those lost to attrition on positive and negative schizotypy scores. The mean interval between the assessments was 10.7 years ($SD = 1.0$). The positive and negative schizotypy dimensions were unassociated with interval length ($r_s = -.04$ and $.06$, respectively).

Materials and Procedures

Initial assessment

The 534 participants who took part in the initial assessment completed face-to-face interviews and were administered the Revised Social Anhedonia Scale and a questionnaire measure of paranoia that contained 36 true/false items, including 10 items from the Minnesota Multiphasic Personality Inventory Scale 6 (University of Minnesota, 1943).

The structured interview included the Schedule for Affective Disorders and Schizophrenia–Lifetime version (SADS-L; Spitzer & Endicott, 1977) sections covering mood, psychotic and substance use disorders, and schizotypal features. The SADS-L was modified to obtain additional information about psychotic-like experiences. The Wisconsin Manual for Assessing Psychotic-like Experiences (Chapman & Chapman, 1980; Kwapil, Chapman, & Chapman, 1999) was used to quantify seven classes of psychotic symptoms across a range of clinical and subclinical deviancy. Kwapil et al. (1999) reported that the highest rating across the seven classes provides a useful index that predicts the development of psychotic disorders. Each participant's rating of schizotypal symptoms was the total number of the 18 criteria endorsed. The Social Adjustment Scale interview (Weissman & Paykel, 1974) was used to quantify social impairment. It produced a total score and subscale scores for social functioning in school, social and leisure, and family settings (with higher scores indicating greater impairment). Participants were assessed for substance use disorders and assigned quantitative ratings of impairment associated with drug and alcohol use (Kwapil, 1996).

10-year follow-up assessment

The follow-up interview assessed overall functioning, psychosis, schizophrenia-spectrum personality disorders, psychotic-like experiences, mood disorders, substance abuse, and mental health treatment. Note that the Wisconsin Schizotypy Scales were not readministered at the follow-up assessment. The interview included a modified SADS-L, the Wisconsin Manual for Assessing Psychotic-like symptoms, and portions of Loranger's (1988) Personality Disorder Exam (PDE) that assessed schizotypal, schizoid, and paranoid personality disorders. The PDE provided both *DSM-III-R* diagnoses and dimensional ratings of the disorders. The Global Adjustment Scale (Endicott, Spitzer, Fleiss, & Cohen, 1976) was used to assess overall functioning for each subject. Participants were rated on a six-point scale of the closeness and quality of intimate relationships. Substance use was assessed in the same manner as at the initial interview.

The interviews, as well as the scoring and diagnosis at both assessments, were conducted by clinical psychologists and advanced graduate students who had received extensive diagnostic training. Interviewers and raters at both assessments were unaware of the subjects' scores on the schizotypy scales. Interviewers and raters at the follow-up were unaware of participants' responses at the initial assessment.

Results

Schizotypy Dimension Scores

Positive and negative schizotypy dimension scores were computed for all 534 participants in the 10-year follow-up study. Schizotypy scores were assigned based on formulae derived from a principal components analysis with a promax rotation of the four Wisconsin Schizotypy Scales using the sample of 6,137 young adults described in Kwapil et al. (2008). Note that this factor structure accounts for 80% of the variance in the Wisconsin Schizotypy Scales, correlates .99 with confirmatory factor analytic derived scores from Kwapil et al., and appears invariant across samples. This is the same procedure used in other studies from our laboratory examining the differential expression of positive and negative schizotypy dimensions (e.g., Barrantes-Vidal et al., 2013; Kaczorowski et al., 2009; Kwapil, Brown, et al., 2012). The formulae (based on raw scores on the scales) are as follows:

Positive schizotypy = (Perceptual Aberration * 0.091)

+ (Magical Ideation * 0.092)

+ (Physical Anhedonia * -0.018)

+ (Social Anhedonia * 0.027) - 1.386

Negative schizotypy = (Perceptual Aberration * 0.006)

+ (Magical Ideation * -0.008)

+ (Physical Anhedonia * 0.089)

+ (Social Anhedonia * 0.096) - 1.936

Consistent with the selection process for the longitudinal study, the mean for the positive schizotypy dimension was higher than for the negative schizotypy dimension; however, the range of scores was comparable for the two dimensions (Positive schizotypy: $M = .95$, $SD = 1.53$, range = -1.96 to 4.63; Negative schizotypy: $M = -.27$, $SD = 1.05$, range = -1.85 to 4.91). The two dimensions were modestly inversely correlated, $r = -.23$, $p < .001$. The positive and negative schizotypy dimensions were uncorrelated with age at each assessment, and with parental socioeconomic status measured at the initial assessment. The positive schizotypy dimension scores were significantly higher in women (women: $M = 1.17$, $SD = 1.48$; men: $M =$

.72, $SD = 1.56$, $p < .01$, Cohen's $d = .30$), and the negative schizotypy dimension scores were significantly higher in men (women: $M = -.47$, $SD = .93$; men: $M = -.04$, $SD = 1.12$, $p < .001$, Cohen's $d = .49$).

Associations of Positive and Negative Schizotypy at the Initial Assessment

In order to assess the validity of the schizotypy dimensions, a series of hierarchical linear and binary logistic regression analyses were computed examining the variance accounted for by the positive and negative schizotypy dimensions and their interaction in the prediction of measures of psychopathology and functioning at the initial and 10-year follow-up assessments. The positive and negative schizotypy dimensions were entered simultaneously in the regression at the first step to examine the relative contribution of each factor. The interaction term was entered at the second step to assess its effect over-and-above the main effects. Note that the Chapman et al.'s (1994) longitudinal study initially used an extreme groups design. However, we believe that regression analyses are appropriate because (a) there were continuous and uninterrupted distributions for the four Wisconsin Schizotypy Scales in the Chapman et al. study, (b) positive and negative schizotypy factor score assignments were based on a large unselected sample, and most importantly, (c) the distributions of the positive and negative schizotypy dimensions were continuous and uninterrupted. Given that a number of the variables had non-normal distributions, bootstrap procedures with 10,000 samples were used for the linear regression analyses. Note that statistical significance for linear regression analyses was only indicated at the .05 and .01 level, because Mplus does not provide bootstrap confidence interval (CI) levels for the upper and lower .05% cutoffs.

Schizophrenia-spectrum psychopathology and functioning

Table 1 presents the linear and logistic regressions at the initial assessment. Positive schizotypy was associated with ratings of psychotic-like, schizotypal, and paranoid symptoms. Negative schizotypy was associated with schizotypal and paranoid symptoms. The positive \times negative schizotypy interaction predicted paranoid symptoms over-and-above the main effects. Simple slopes analysis of the interaction term revealed that positive schizotypy significantly predicted paranoid symptoms at all levels of negative schizotypy, but this relation strengthened as negative schizotypy increased. This was the case for low ($\beta = 0.38$), moderate ($\beta = 0.51$), and high ($\beta = 0.64$, all slopes $p < .001$) levels of negative schizotypy (low reflects $-1 SD$, moderate is the mean, and high is $+1 SD$). Both positive and negative schizotypy dimensions were associated with impaired functioning as assessed by the Social Adjustment Scale total and subscale scores.

Table 1 *Linear and Logistic Regressions of Measures at the Initial Assessment ($n = 534$)*

Multiple linear regressions with 10,000 bootstrap samples						
Dependent	Step 1				Step 2	
	Positive schizotypy		Negative schizotypy		Interaction	
	β	Δr^2	β	Δr^2	β	Δr^2

variable						
Highest psychotic-like experience	.469**	.209	.040	.002	.041	.002
Schizotypal symptoms	.529**	.265	.160**	.024	.061	.003
Paranoia questionnaire	.518**	.254	.227**	.049	.140**	.018
Social Adjustment Scale: total	.241**	.055	.402**	.153	.059	.003
Social Adjustment Scale: school	.140**	.018	.114**	.012	.096*	.009
Social Adjustment Scale: leisure	.177**	.030	.451**	.192	.061	.003
Social Adjustment Scale: family	.287**	.078	.305**	.088	.001	.000
RDC depressive symptoms	.341**	.110	.016	.000	.086	.007
RDC mania symptoms	.278**	.073	.020	.000	.020	.000
Impairment from alcohol use	.188**	.034	.042	.002	.028	.001
Impairment from drug use	.145**	.020	.032	.001	.050	.002
Binary logistic regressions						
	Step 1				Step 2	
	Positive schizotypy		Negative schizotypy		Interaction	
Dependent variable	OR	95% CI	OR	95% CI	OR	95% CI
Alcohol abuse/dependence	1.22*	1.03, 1.45	1.10	0.86, 1.40	0.98	0.78, 1.23
Drug abuse/dependence	1.31**	1.11, 1.56	0.88	0.67, 1.15	1.10	0.85, 1.42

Note. RDC = Research Diagnostic Criteria; OR = odds ratio; CI = confidence interval. * $p < .05$.

** $p < .01$.

Mood symptoms and substance abuse

As hypothesized, positive, but not negative, schizotypy was associated with mood disturbances and substance abuse. Positive schizotypy was associated with increased ratings of depressive and

manic symptoms. In addition, it was associated with elevated rates of substance use disorders and with quantitative ratings of impairment associated with alcohol and drug use.

Associations of Positive and Negative Schizotypy at the Reassessment

Schizophrenia-spectrum psychopathology

Table 2 presents the linear and logistic regressions of positive and negative schizotypy at the initial assessment predicting outcomes at the 10-year follow-up assessment. Positive schizotypy was associated with the development of psychotic disorders at the follow-up, whereas both positive and negative schizotypy were significantly associated with the development of schizophrenia-spectrum disorders (including both psychotic disorders and cluster A personality disorders). Note that the odds ratios (ORs) for the prediction of psychotic disorders were comparable for positive and negative schizotypy, but only attained statistical significance for positive schizotypy. This may reflect that the sample had a higher rate of high scorers on positive than on negative schizotypy and thus provided a more stable estimate of the effects for positive, than for negative, schizotypy. Both schizotypy dimensions were associated with ratings of psychotic-like experiences and schizotypal and paranoid personality traits. In addition, negative schizotypy was associated with ratings of schizoid personality traits. Consistent with the initial interview, the positive \times negative schizotypy interaction predicted paranoid traits. Simple slope analysis revealed that the relation between positive schizotypy and paranoid personality traits was significant at moderate ($\beta = 0.22$; $p < .001$) and high ($\beta = 0.35$; $p < .001$) levels of negative schizotypy, but not at low levels ($\beta = 0.094$).

Table 2 *Linear and Logistic Regressions of Measures at the 10-Year Follow-Up ($n = 508$)*

Multiple linear regressions with 10,000 bootstrap samples						
Dependent variable	Step 1				Step 2	
	Positive schizotypy		Negative schizotypy		Interaction	
	β	Δr^2	β	Δr^2	β	Δr^2
Highest psychotic-like experience	.369**	.127	.090*	.008	.103	.010
Paranoid personality rating	.224**	.047	.160**	.024	.137*	.017
Schizotypal personality rating	.325**	.099	.189**	.034	.083	.006
Schizoid Personality rating	.005	.000	.260**	.064	-.054	.003
Global adjustment scale	-.268**	.068	-.124**	.015	-.072	.005
Relationship closeness	-.040	.002	-.208**	.041	-.052	.002

Impairment from alcohol use	.118*	.013	.061	.003	.018	.000
Impairment from drug use	.243**	.056	-.070	.005	.016	.000
Binary logistic regressions						
	Step 1				Step 2	
	Positive schizotypy		Negative schizotypy		Interaction	
Dependent variable	OR	95% CI	OR	95% CI	OR	95% CI
Any psychotic disorder	1.49*	1.04, 2.13	1.49	0.95, 2.35	1.21	0.79, 1.85
Any schizophrenia-spectrum disorder	1.50**	1.16, 1.94	1.87***	1.37, 2.55	1.02	0.77, 1.35
Ever married	0.93	0.82, 1.04	0.74**	0.62, 0.89	0.88	0.73, 1.06
Any mental health treatment	1.17*	1.03, 1.32	0.85	0.71, 1.02	1.06	0.88, 1.27
Major depressive episode	1.37***	1.20, 1.58	1.00	0.81, 1.23	1.19	0.96, 1.49
Manic/hypomanic episode	1.82***	1.34, 2.47	1.30	0.87, 1.95	0.91	0.65, 1.30
Any suicide attempt	1.58*	1.11, 2.27	0.91	0.52, 1.60	1.67	0.93, 3.01
Alcohol abuse/dependence	1.19*	1.02, 1.38	1.13	0.91, 1.40	0.99	0.80, 1.22
Drug abuse/dependence	1.25**	1.06, 1.48	0.87	0.66, 1.14	1.09	0.84, 1.42

Note. OR = odds ratio; CI = confidence interval. * $p < .05$. ** $p < .01$. *** $p < .001$.

The same interview measure of psychotic-like experiences was administered at both assessments and correlated .36 across the two interviews. In order to examine whether the schizotypy dimensions predicted worsening psychotic-like experiences across the 10-year interval, we recomputed the regression analysis predicting psychotic-like experiences at the follow-up after partialing out variance associated with psychotic-like experiences at the initial interview. The prediction of follow-up psychotic-like experiences remained significant for both positive ($\beta = 0.25$; $p < .001$) and negative ($\beta = 0.08$; $p < .05$) schizotypy. Although different measures were used at the two assessments, the correlations across assessments of ratings of schizotypal ($r = .34$) and paranoid ($r = .34$) symptoms were significant. We recomputed the regression analyses partialing out the baseline measures. The prediction of schizotypal symptoms remained significant for both positive ($\beta = 0.20$; $p < .001$) and negative ($\beta = 0.15$; $p < .01$) schizotypy. Likewise, the prediction of paranoid symptoms remained significant for both positive ($\beta = 0.10$; $p < .05$) and negative ($\beta = 0.11$; $p < .05$) schizotypy.

Functioning and mental health treatment

Both positive and negative schizotypy predicted impaired functioning as assessed by the Global Adjustment Scale. Negative, but not positive, schizotypy was associated with diminished closeness of significant relationships and with diminished likelihood of having married. Positive schizotypy was associated with increased likelihood of receiving mental health treatment (including hospitalization, pharmacotherapy, or psychotherapy).

Mood disorders and substance abuse

As hypothesized, positive, but not negative, schizotypy was associated with mood disturbances and substance abuse. Positive schizotypy was associated with increased likelihood of major depressive and manic or hypomanic episodes, as well as with increased rates of suicide attempts. Family members indicated that two participants committed suicide between the initial and follow-up assessments. Both of these participants had elevated scores on the positive, but not the negative, schizotypy dimension (positive schizotypy standard scores of 2.48 and 2.65). Positive schizotypy was associated with elevated rates of substance abuse and dependence disorders and with quantitative ratings of impairment associated with alcohol and drug use.

As hypothesized, the positive and negative schizotypy dimensions were associated with differential patterns of symptoms and impairment. However, one question is whether the dimensions actually perform better than the original group assignment. Therefore, we reran the regression analyses for five primary dependent measures at the 10-year follow-up (global adjustment, psychotic-like experiences, and schizotypal, schizoid, and paranoid personality disorder symptoms) after partialing out variance associated with group membership. Specifically, we created four dummy codes that compared Chapman et al.'s (1994) Perceptual Aberration/Magical Ideation, Physical Anhedonia, Impulsive-Nonconformity, and combined groups with the control group, following guidelines from Cohen, Cohen, West, and Aiken (2003). We entered the dummy codes as a block in the regression analysis prior to entering the schizotypy dimension scores. The findings for the positive and negative schizotypy dimensions were unchanged (negative schizotypy still significantly predicted all five criteria and positive schizotypy significantly predicted all the criteria except schizoid symptoms). In contrast, almost none of the dummy codes remained significant after entering the schizotypy dimensions.

Post Hoc Analyses

We conducted a number of post hoc analyses in response to recommendations of the reviewers to further examine the nature of the associations of positive and negative schizotypy with outcomes at the assessments. First, we examined whether the schizotypy dimensions predicted psychotic or schizophrenia-spectrum disorders at the follow-up assessment over-and-above the effects of family history of psychosis in first degree relatives. Note that 15 participants reported a first-degree relative with psychosis, and neither the positive schizotypy nor negative schizotypy dimensions were associated with family history, $r = -.03$ and $.06$, respectively. In each logistic regression analysis family history of psychosis in a first-degree relative was entered at Step 1,

and the schizotypy factors were entered together at Step 2. Family history significantly predicted psychotic disorders at the follow-up assessment, OR = 6.17, 95% CI [1.25, 30.40], $p < .05$. Furthermore, positive schizotypy still predicted psychotic disorders, OR = 1.53, 95% CI [1.06, 2.20], $p < .05$, although negative schizotypy did not, OR = 1.47, 95% CI [0.92, 2.33]. Similarly, family history significantly predicted schizophrenia-spectrum disorders at the follow-up assessment, OR = 6.53, 95% CI [1.95, 21.92], $p < .01$. Both positive schizotypy, OR = 1.53, 95% CI [1.18, 1.99], $p < .01$, and negative schizotypy, OR = 1.86, 95% CI [1.35, 2.56], $p < .001$, still predicted spectrum disorders over-and-above family history.

Given that the Chapmans' original sample was initially selected using an extreme groups approach, a reviewer recommended analyses of weighted data to correct for sampling bias. Therefore, we computed a sampling weight for each subject based on the product of the probability of their positive and negative schizotypy scores (using norms from our original derivation sample). We then recomputed the regression analyses for our primary schizotypy-dependent measures at the follow-up (Global Assessment of Functioning score, psychotic-like experiences, schizotypal, schizoid, and paranoid personality dimensional scores) using the Mplus WEIGHT option. The results were substantively unchanged, with the exception that negative schizotypy no longer significantly predicted psychotic-like experiences at the follow-up assessment. These results are presented in Supplemental Table S1.

We also calculated the prediction of quantitative outcome measures at the initial and follow-up assessment separately for the positive and negative schizotypy factors (as opposed to our planned analyses that entered them simultaneously into the regression models). Note that the statistical significance of these zero-order associations was largely unchanged from the initial regressions. These results are reported in Supplemental Table S2.

Following a reviewer's recommendation, we recalculated all of the linear and logistic regressions after removing variance associated with gender. Note that in every reanalysis, gender (coded 1 = men, 2 = women) was entered at the first step, and the positive and negative schizotypy dimension scores were entered simultaneously at the second step. Note that none of the effects for positive and negative schizotypy were substantively changed after partialing out variance associated with gender (see Supplemental Table S3). Thus, although there are gender differences in positive and negative schizotypy, the cross-sectional and longitudinal predictions of psychopathology and impairment by psychometric schizotypy were not accounted for by gender.

The primary goal of the study was to examine the association of the positive and negative schizotypy dimensions with symptoms and impairment at the initial and 10-year follow-up assessments. However, a reviewer raised concerns about the need to test the relative predictive strength of the two schizotypy dimensions (i.e., whether the positive and negative schizotypy regression coefficients differed significantly). The most elegant method is to examine whether the 95% CIs around one standardized coefficient include the other coefficient. In other words, if the 95% CI around the beta for positive schizotypy's prediction of psychotic-like experiences

does not include the beta value for negative schizotypy, we can reject that null that $\beta_{\text{positive}} = \beta_{\text{negative}}$. However, MPlus does not provide bootstrapped CIs for standardized coefficients (beta) in its output. As a solution, we computed nonbootstrapped CIs around the standardized coefficients and examined whether they overlapped. Note that this appears to be an acceptable solution given that (a) bootstrapping does not change the coefficient values, just the estimation of standard errors and (b) the statistical significance did not change for any of the regression coefficients when the bootstrapped and nonbootstrapped results were compared. The results with the nonbootstrapped CIs are presented in Supplemental Table S4. The betas for positive and negative schizotypy were significantly different for 14 of the 19 analyses. However, we caution readers to consider the larger pattern of findings across multiple studies, given that this study was not specifically designed to assess the positive and negative schizotypy dimensions.

Discussion

Early psychiatric models suggested that psychosis represented a discontinuity such that one either did or did not have a psychotic illness (and “never the twain shall meet”). However, increasing evidence from multiple sources such as community studies (e.g., van Os, Hanssen, Bijl, & Ravelli, 2000), family studies (e.g., Kendler, McGuire, Gruenberg, & Walsh, 1995), and studies of the prodrome (e.g., Woods et al., 2009) and high-risk designs (e.g., Gooding, Tallent, & Matts, 2005) indicates that brief, transient, and subclinical psychotic symptoms are not uncommon and that these symptoms may presage the development of schizophrenia-spectrum disorders. Schizotypy provides a powerful unifying framework for integrating subclinical manifestations, the prodrome, spectrum disorders, and full-blown psychosis. Schizotypy also allows us to consider risk and protective factors, facilitates the search for endophenotypes, and involves a multidimensional structure that takes into account the heterogeneous nature of etiology, expression, and treatment response. Furthermore, consideration of a multidimensional model of schizotypy should facilitate the mapping of psychosis and psychotic-like symptoms onto comprehensive models of psychopathology (e.g., Markon, 2010; Wright et al., 2013) and dimensional models of personality pathology (e.g., Krueger et al., 2011). However, reliable and valid measurement of these dimensions is essential for furthering our understanding of schizotypy and schizophrenia.

The concurrent validity of psychometrically assessed positive and negative schizotypy has been supported in interview, questionnaire, laboratory, and daily life studies. However, the present findings provided the first evidence of the predictive validity of these dimensions by demonstrating that positive and negative schizotypy are associated with hypothesized patterns of symptoms and impairment in a 10-year follow-up of nonclinically ascertained young adults. The Chapmans’ longitudinal data set provides an ideal starting place for assessing the predictive validity of the dimensions because of its large sample size, high reassessment rate, 10-year time interval, and inclusion of criteria relevant to the construct of schizotypy. Although the results are not completely surprising in light of the findings for the individual scales in Chapman et al. (1994) and Kwapił (1998), the present findings make a unique contribution over those original

results by assessing and supporting the validity of a conceptually driven dimensional model of schizotypy. Nevertheless, new prospective studies should be launched to attempt to replicate these findings in independent samples. Furthermore, such future studies would benefit from inclusion of measures of negative symptoms and the prodrome, as well as consideration of other schizotypy dimensions such as cognitive and behavioral disorganization. However, given the cost and time required to conduct longitudinal assessments, use of the Chapman's longitudinal sample provided a unique opportunity to assess the validity of the positive and negative dimensions to predict psychopathology and impairment, and most importantly, the development of schizophrenia-spectrum disorders at the 10-year follow-up.

As hypothesized, the dimensions showed differential patterns of associations at both the initial and follow-up assessments, such that positive schizotypy was associated with psychotic-like symptoms, mood disorders, substance abuse, and mental health treatment, whereas negative schizotypy was related to schizoid traits and diminished closeness of significant relationships. Furthermore, additional analyses indicated that positive schizotypy predicted the development of psychotic disorders and both dimensions predicted the development of schizophrenia-spectrum disorders over-and-above family history of psychosis. As expected, both dimensions were associated with schizotypal and paranoid traits and impaired functioning. These findings are consistent with Kwapil et al.'s (2008) cross-sectional interview study of 430 young adults, but also provide evidence that these dimensions are useful in longitudinally predicting schizophrenia-spectrum disorders. The results also indicated that the dimensions provided superior prediction relative to the original nominal groups used in Chapman et al. (1994). Converging evidence indicates that positive and negative schizotypy are related but qualitatively different phenotypes, with different etiologies and underlying pathophysiology. Despite this, researchers often treat schizotypy and schizophrenia as homogenous constructs. We suggest that failure to differentiate the multidimensional structure of schizotypy and schizophrenia will confound signal and noise and impede our ability to elucidate relevant etiological factors.

Consistent with previous findings in the schizotypy literature (e.g., Miettunen & Jääskeläinen, 2010; Raine, 1992), women scored higher than men on the positive schizotypy dimension (small effect size) and men scored higher on the negative schizotypy dimension (medium effect size). However, these gender differences did not account for the association of the positive and negative schizotypy dimensions with measures of symptoms and impairment at the cross-sectional or longitudinal assessments. Note that the analyses of gender differences and effects in this study should be interpreted cautiously as these were largely post hoc examinations and the study was not specifically designed to examine gender differences.

The positive and negative schizotypy dimensions predicted schizophrenia-spectrum symptoms and disorders at the 10-year follow-up. An obvious concern is that this may simply reflect baseline effects at the initial assessment; however, several factors speak against this. First, the participants were all functioning well enough at the initial assessment to attend a major university and had only just entered the age of greatest risk for developing spectrum disorders.

As noted, both schizotypy dimensions predicted psychotic-like, schizotypal, and paranoid ratings at the follow-up over-and-above ratings at the initial interview. In terms of disorders, none of the participants met criteria for psychotic illnesses at the initial assessment, although 14 had done so at the time of the follow-up. Unfortunately, Chapman et al. (1994) did not diagnose schizophrenia-spectrum personality disorders at the initial assessment, so we cannot definitively state the extent to which spectrum personality disorders diagnosed at the follow-up assessment were present at the initial assessment. However, several lines of evidence suggest that the rates at the initial assessment would likely be low. Using a subset of 180 participants from the Chapman et al. study, Kwapil (1998) used extant information to make *DSM-III-R* schizotypal, schizoid, and paranoid personality disorder diagnoses for participants at the initial assessment. Only one of 180 (.6%) met criteria for a schizophrenia-spectrum personality disorder diagnosis at the initial assessment. Similarly, two cross-sectional interview studies assessed large samples of college students with an overrepresentation of high scorers on the positive and negative schizotypy dimensions. Kwapil et al. (2008) reported that only seven of 430 (1.6%) met criteria for schizotypal, schizoid, or paranoid personality disorders, and Barrantes-Vidal et al. (2013) reported a rate of five of 214 (2.3%) for these disorders. So, the evidence suggests that the dimensions predicted symptoms at the cross-sectional assessment and the development of symptoms and disorders at the follow-up assessment.

Chapman et al. (1994) reported that their group identified by high scores on the Physical Anhedonia Scale did not have elevated rates of psychotic disorders, elevated ratings of psychotic-like or schizophrenia-spectrum personality disorder traits, or impaired functioning compared with the control group at the follow-up assessment. In contrast, the negative schizotypy dimension, which includes comparable loadings from both anhedonia scales, was significantly associated with schizophrenia-spectrum disorders, symptoms, and impairment (over-and-above variance accounted for by positive schizotypy). Furthermore, the findings for the negative schizotypy dimensional score are as good or superior to the findings for the Revised Social Anhedonia Scale reported by Kwapil (1998), suggesting that the effectiveness of the Revised Social Anhedonia Scale as a predictor is not “diluted” by the inclusion of variance from the Physical Anhedonia Scale. We suggest that the combination of variance from the two anhedonia scales provides a richer assessment of the negative schizotypy dimension than either scale individually.

The finding that the positive and negative schizotypy interaction term generally did not account for additional variance is consistent with our previous studies and suggests that the effects of the dimensions tend to be additive. This additive effect is clearly demonstrated in Barrantes-Vidal, Lewandowski, and Kwapil’s (2010) findings of marked deviancy for a combined positive and negative schizotypy cluster. Of note, significant interactions were found at both assessments for measures of paranoia—despite the fact that these were assessed 10 years apart and that the initial assessment used a trait-based questionnaire of paranoia, whereas the follow-up used an interview for paranoid personality disorder. It is not entirely clear why this interaction occurred specifically

for paranoia. Bentall et al. (2009) described that paranoia has a wide variety of emotional (e.g., negative affect, low self-esteem) and social–cognitive (e.g., poor ability to reason about the mental states of others) mechanisms that appear to be differentially related to positive and negative schizotypy. Thus, high levels of paranoia may require this synergistic combination of affective and cognitive deficits associated with positive and negative schizotypy. However, this bears further investigation in both cross-sectional and longitudinal studies.

One possible criticism is that the assignment of factor scores for positive and negative schizotypy involved the use of formulae based on college students norms from data collected in another state and approximately two decades after the participants in the Chapmans' sample were assessed. Unfortunately, it was not possible to assess the factor structure of the screening cohort from which the longitudinal samples was drawn. However, we have found that the factor structure is robust and invariant across time, location, and language. In fact, the factor scores from our formulae correlated .999 with factor scores derived from principal component analyses of recent samples collected in Spain (Kwapil, Ros-Morente, et al., 2012) and from unpublished data collected in Wisconsin in the early 1990s. Obviously, the most robust demonstration of the utility of the dimension scores comes from the validity findings in the present and recent studies.

An additional concern is that the differential findings for positive and negative schizotypy are simply due to psychometric differences in discriminating power between the dimensions. However, we believe that is not the case. The schizotypy dimensions have been replicated in both exploratory and confirmatory factor studies. The factor structure is stable, and both factors account for a large portion of the variance in the underlying measures. Furthermore, the individual scales used to derive the factors all have good internal consistency and test–retest reliability. Second, Gross et al. (2013) reported that the 10-week test–retest reliabilities of the positive and negative schizotypy dimensions are .81 and .82, respectively. Furthermore, it is important to note that the present findings are part of a larger series of studies that have reported hypothesized differential patterns of associations of the positive and negative schizotypy dimensions with questionnaire, interview, biobehavioral, and daily life experiences. If the results were simply due to one of the dimensions being more psychometrically discriminating, we would expect to primarily find significant effects for that dimension.

In summary, we believe that advancement of our understanding of schizotypy and schizophrenia requires conceptual and empirical consideration of the underlying multidimensional structure of these constructs. In turn, this requires reliable and valid measurement of these dimensions. The present study provided the first evidence of the predictive validity of psychometrically assessed positive and negative schizotypy, and it points the way for continued conceptualization and validation.

Footnotes

1 Unpublished test copies of the *Revised Social Anhedonia Scale* are available from the corresponding author Thomas R. Kwapil.

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